Canadian AMSR-E Snow Science Activities: Evaluation of AMSR-E Data for Snow Water Equivalent Retrieval

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<u>Outline</u>

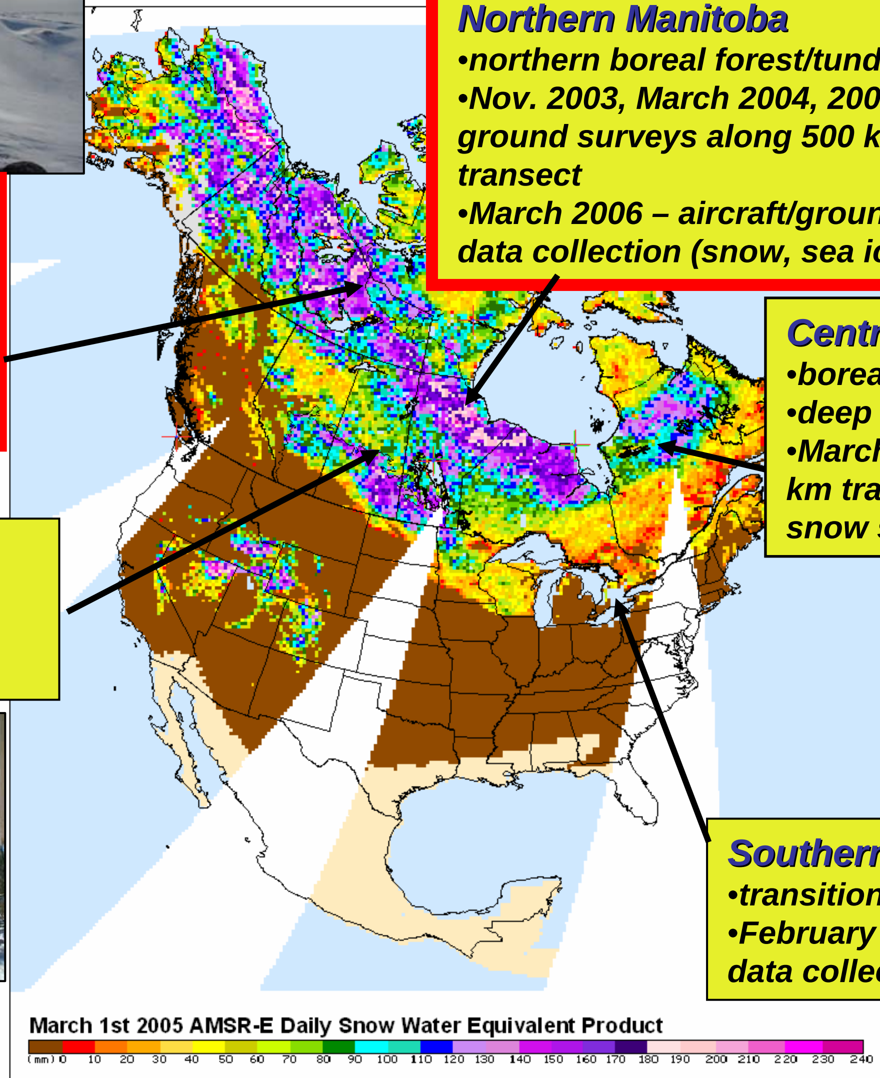
- Overview of airborne/field campaigns
- Brightness temperature relationships with snow cover
    - Deep vs. shallow snow
    - Lake fraction
    - Vegetation
- SWE Product Assessment

Joint AMSR-E Science Team Meeting, September 6-8, 2006, La Jolla

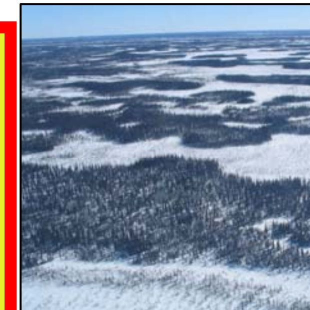
AMSR-E Snow Cover Validation Campaigns in Canada

Northwest Territories
- tundra snow, lake ice
- April 2004 – ground surveys
- April 2005 – aircraft/ground data collection
- April 2006 – ground surveys

Canadian Prairies
- agricultural/boreal forest
- February 2003 – aircraft/ground data collection



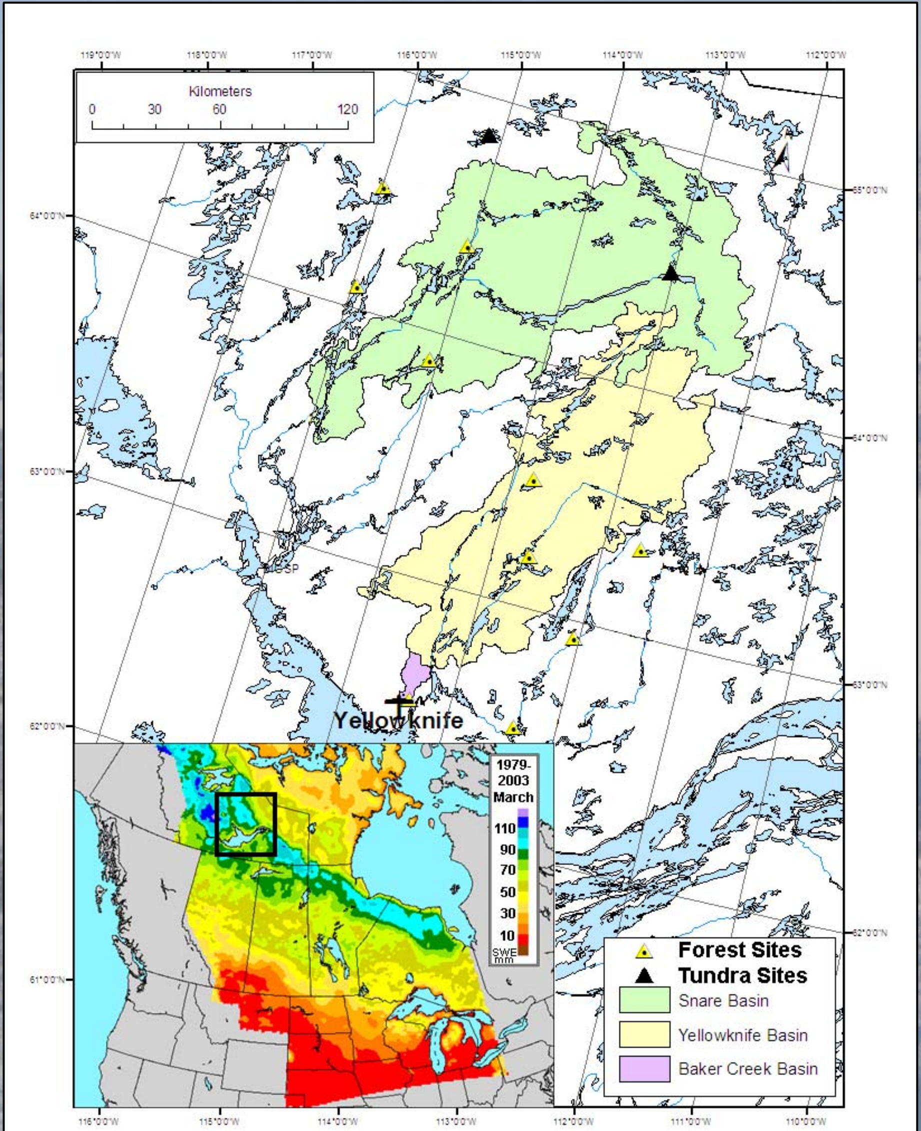
Northern Manitoba
- northern boreal forest/tundra
- Nov. 2003, March 2004, 2005 – ground surveys along 500 km transect
- March 2006 – aircraft/ground data collection (snow, sea ice)



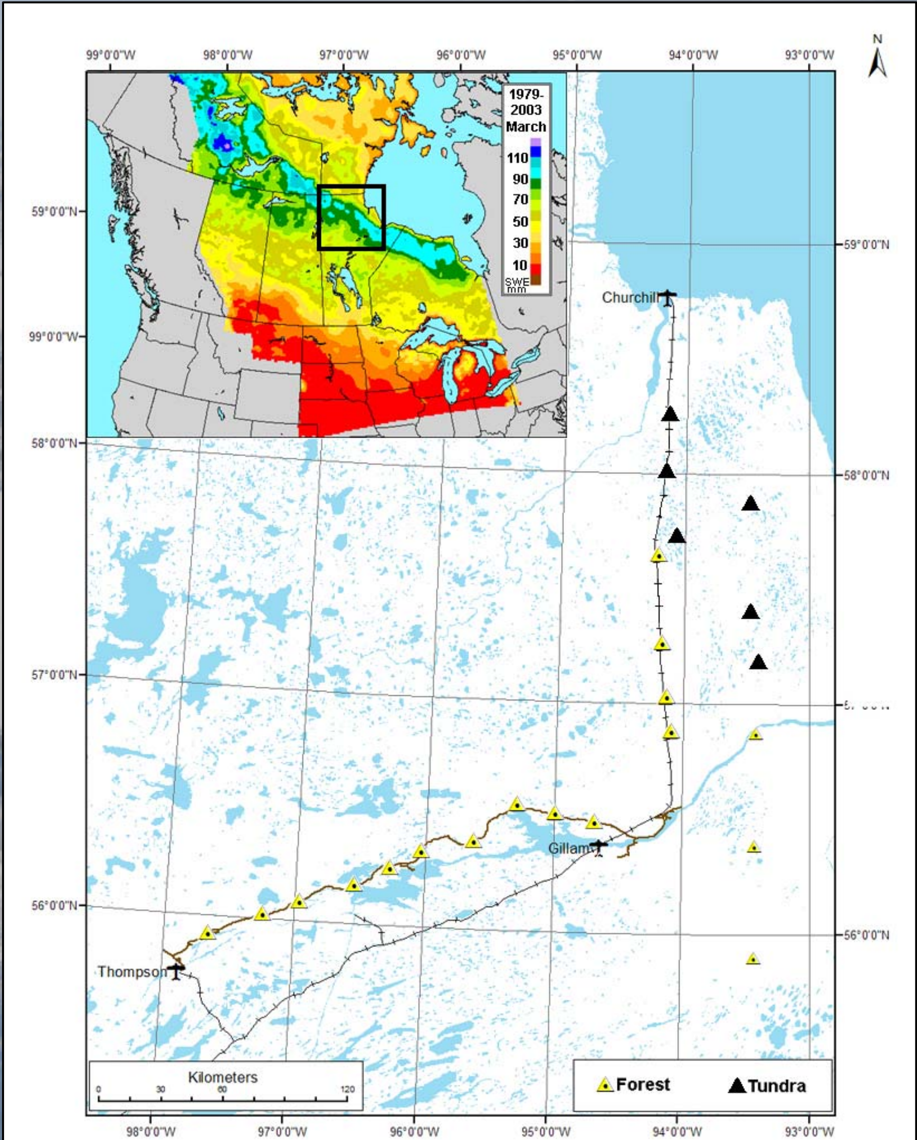
Central Quebec
- boreal forest/taiga
- deep snow cover (150 mm+)
- March 2003 ground survey (800 km transect); Hydro Quebec snow surveys (2003-2004)

Southern Ontario
- transitional snow cover
- February 2004 – aircraft/ground data collection

2005-2006 Northern Airborne/Field Campaigns



Northwest Territories, April 2005



Manitoba, March 2006

- Ground measurements acquired at all sites for both years
- Data available at www.ccin.ca

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Airborne Microwave Radiometer Data

- Environment Canada radiometers (6.9, 19, 37, 89 GHz dual polarization) deployed on Twin Otter aircraft
- Pre- and post flight calibration performed using warm (Echosorbe) and cold (liquid nitrogen) reference points
- Brightness temperature uncertainties of approximately:
  - 8K at 6.9 GHz
  - 1K at 19 GHz
  - 0.5K at 37GHz
  - 2K at 89 GHz

- RFI in the vicinity of airports adversely affected calibration at 6.9 GHz although RFI rarely detected during flight

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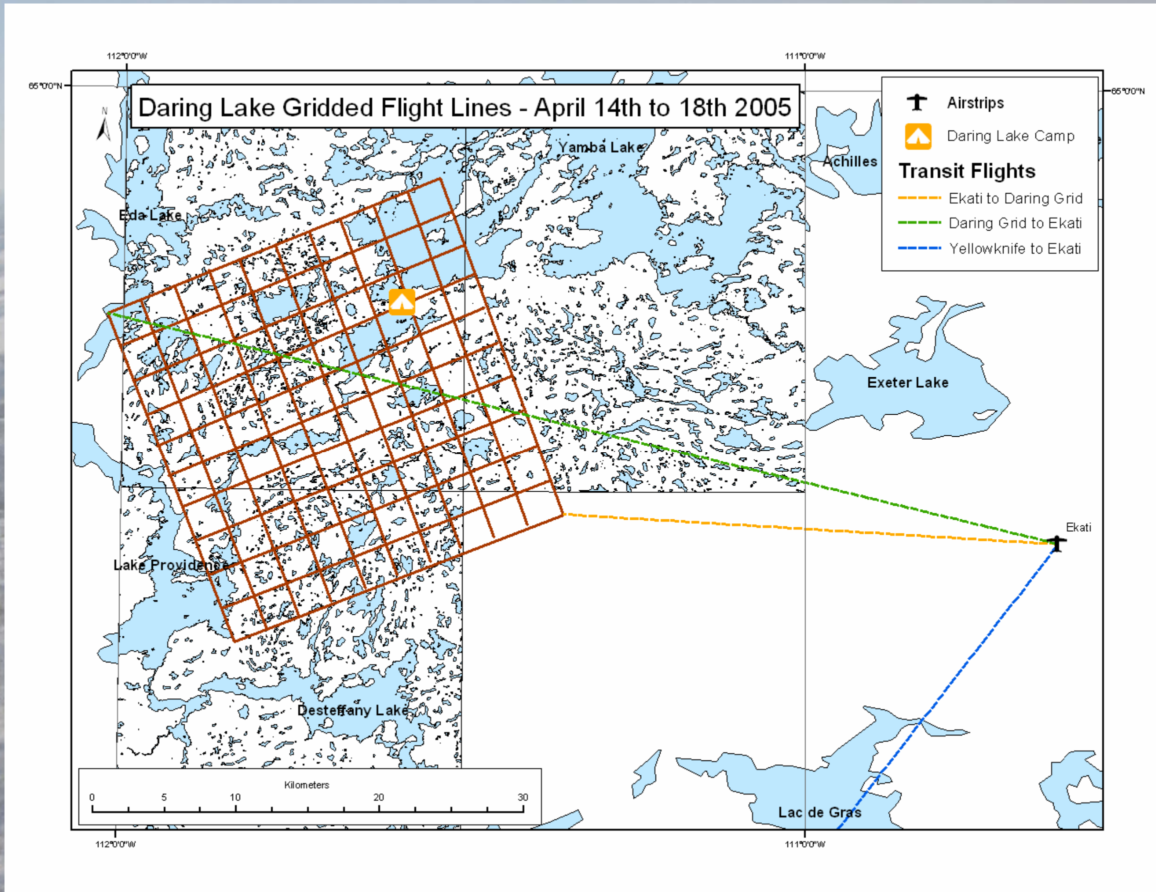
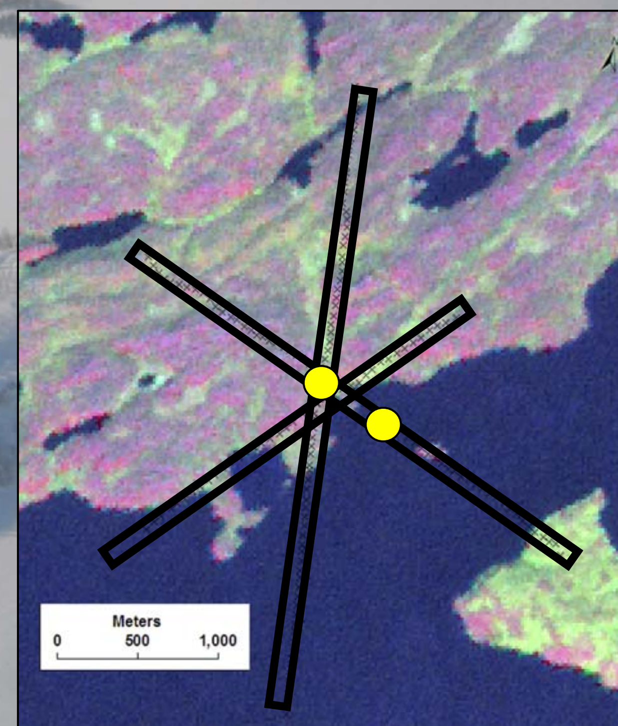
Airborne Data Collection

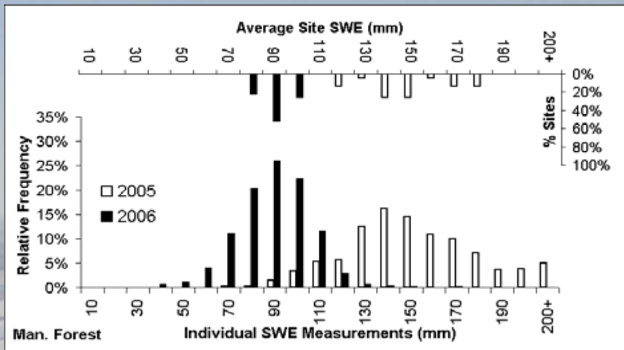


- Data acquired across grids corresponding to AMSR-E grid cells

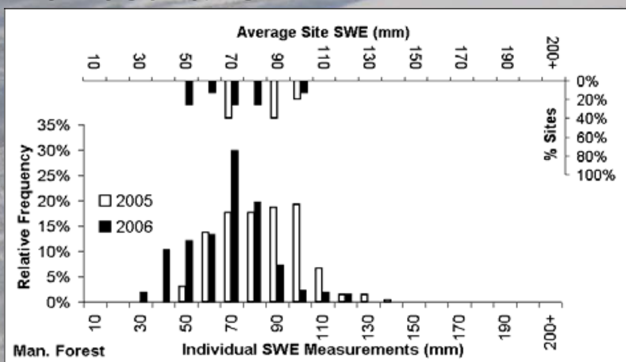


- Data acquired in radial patterns of short flight line segments centered on ground measurement locations (~3 x 3 km)

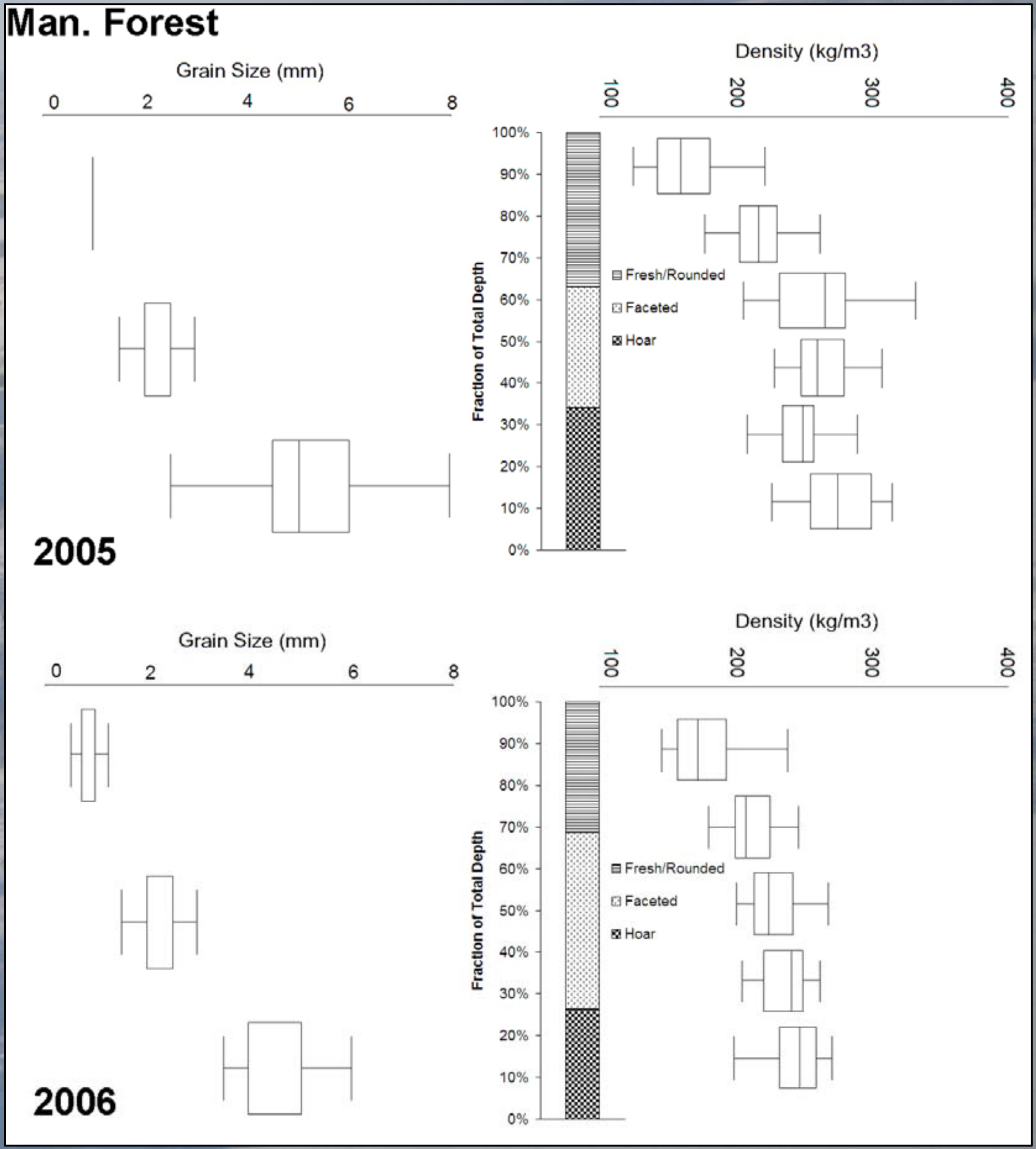
Ground Snow Measurements



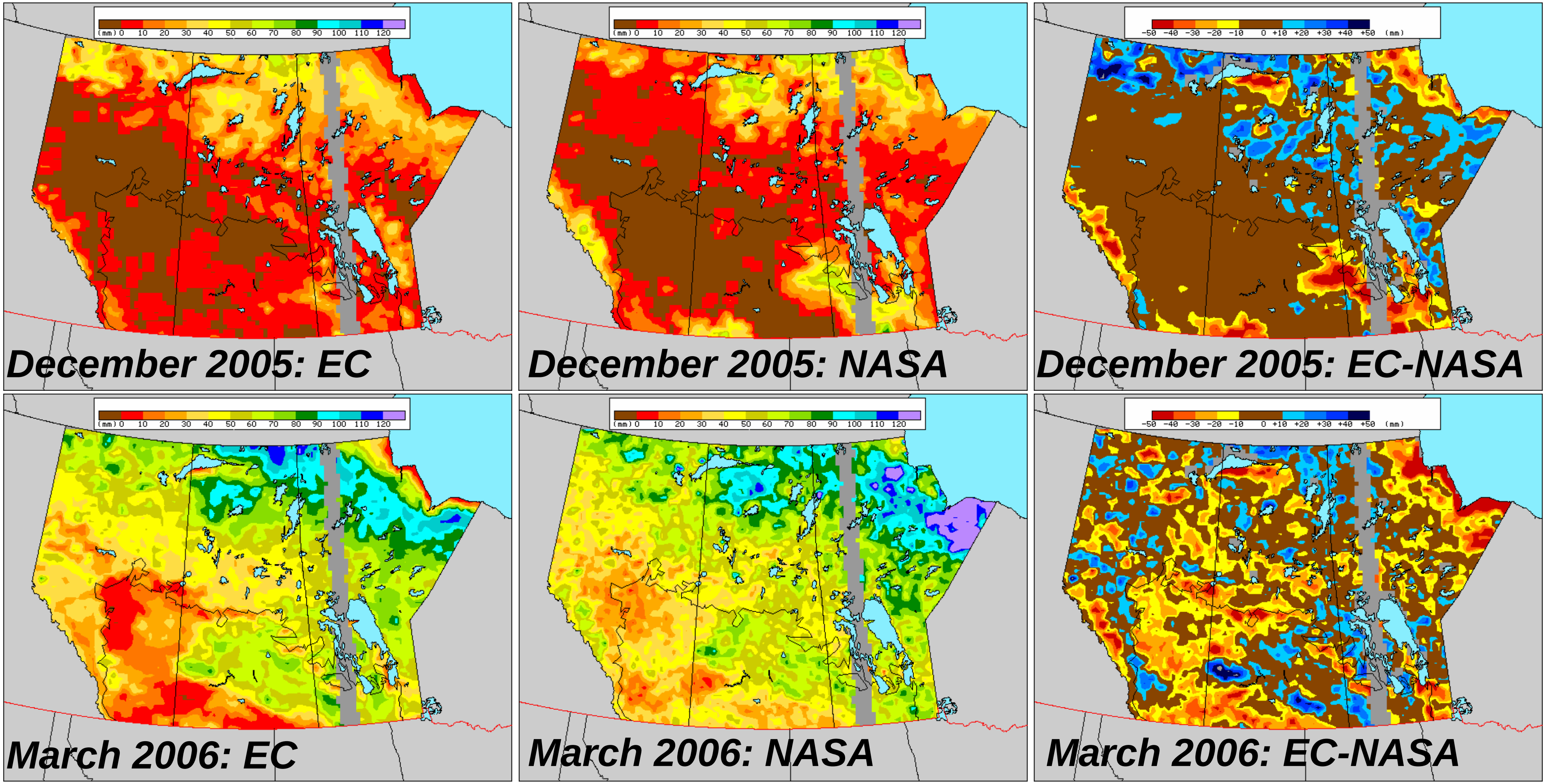
Terrestrial SWE



SWE on Lakes



SWE Algorithm Intercomparison (EC vs NASA)



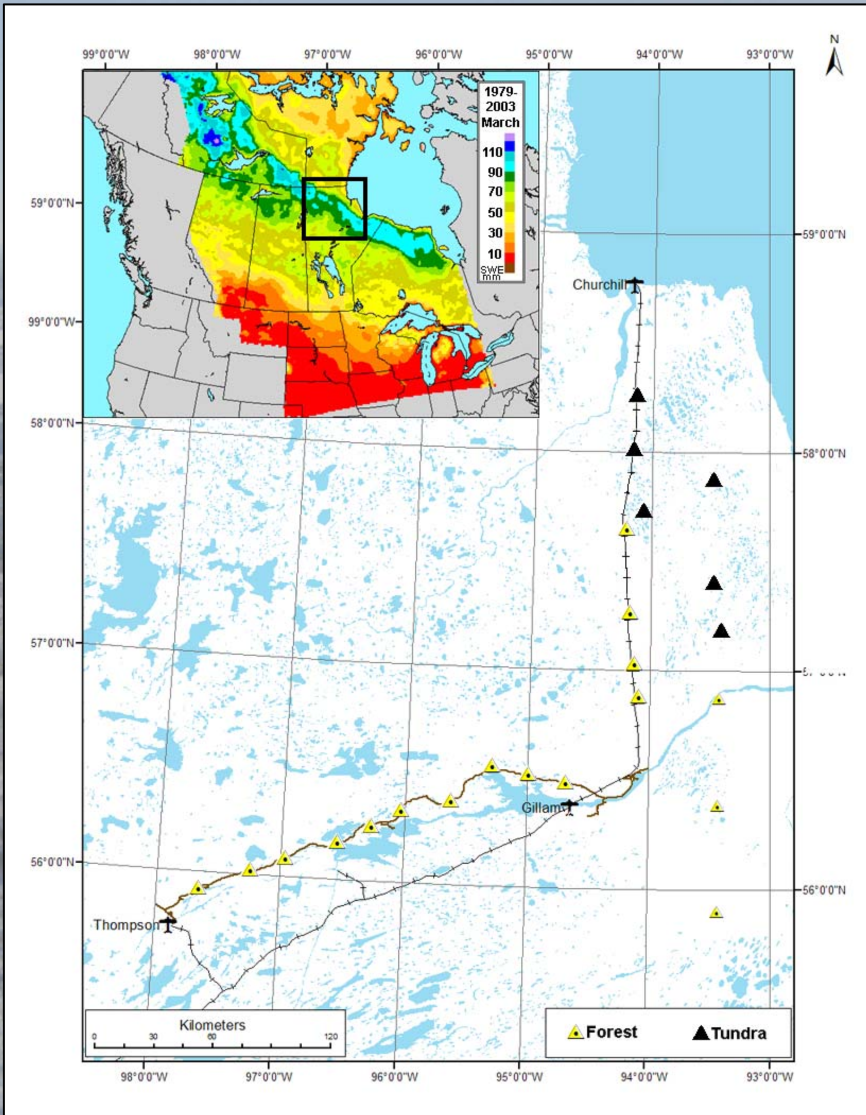
December:

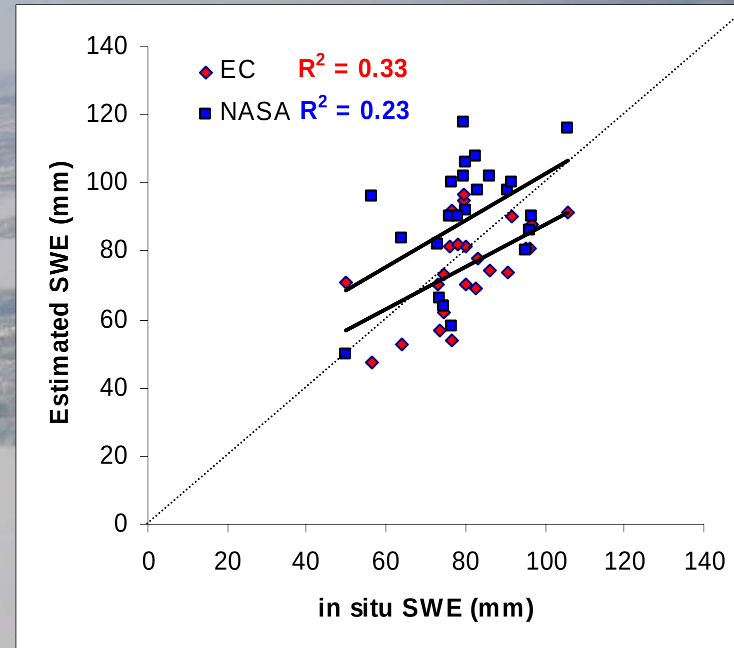
- Slightly higher SWE in NASA product
- Slightly higher SCA in EC product
- No clear direction of disagreement

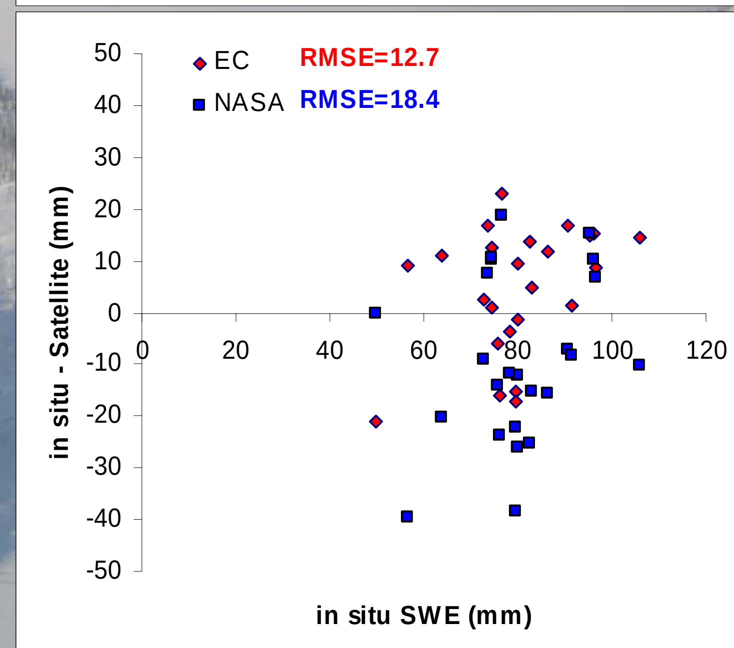
March:

- Slightly higher SWE in NASA product
- No clear direction of disagreement

SWE Algorithm Intercomparison – Northern Manitoba







26 February– 3 March 2006, near peak SWE

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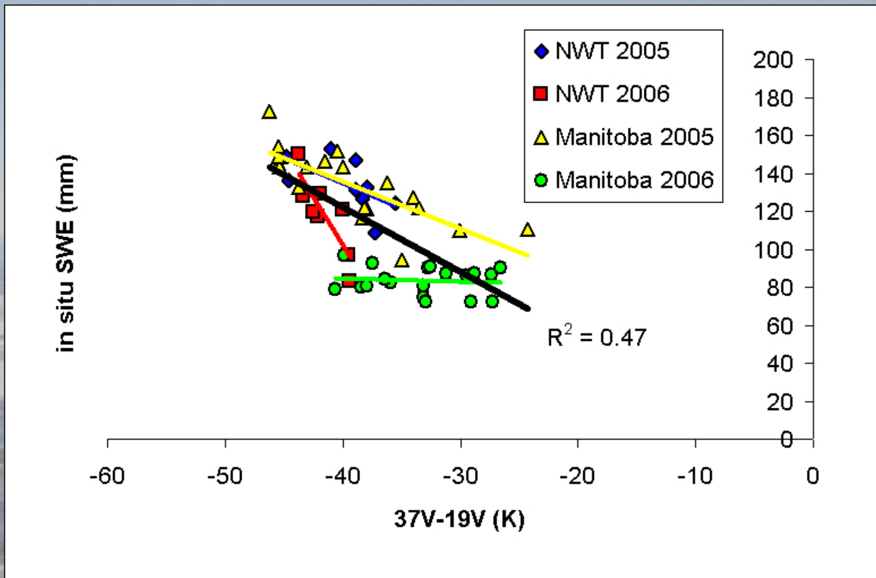
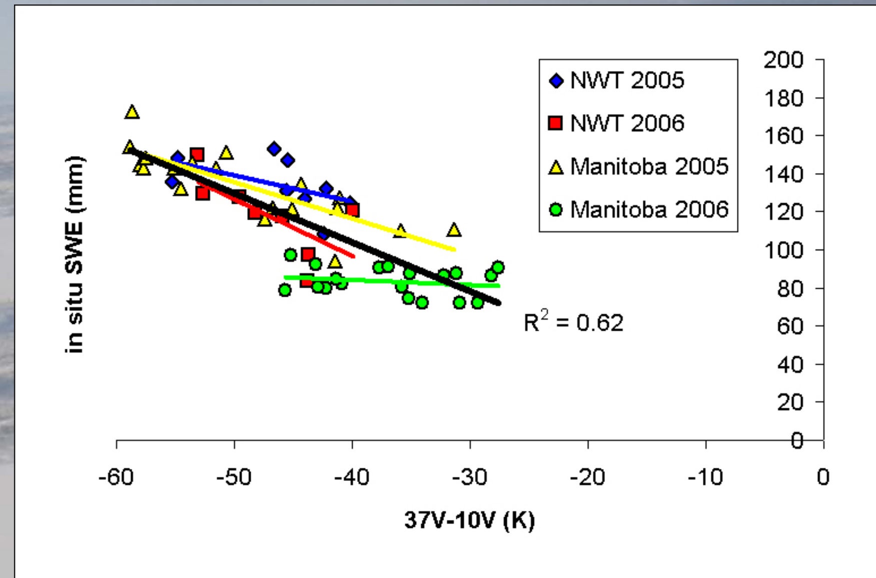
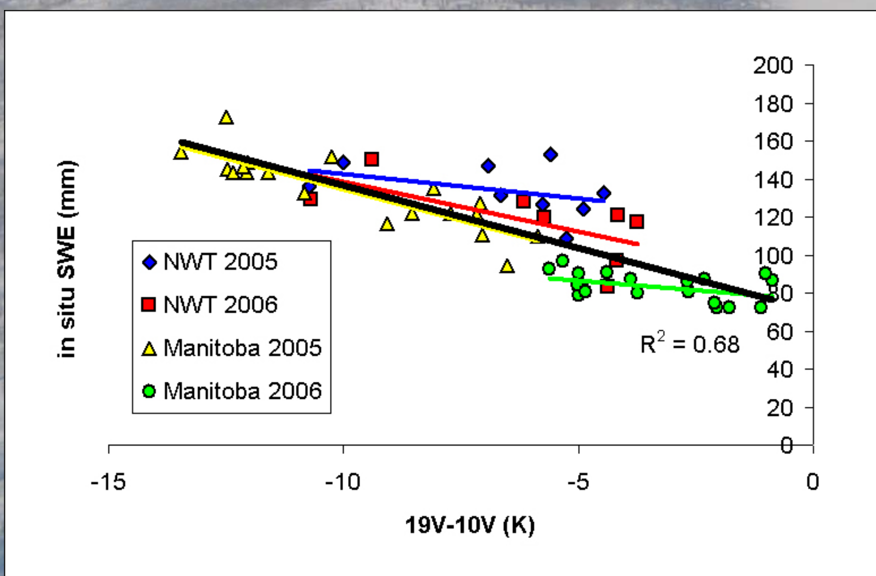
Coarse Resolution Relationships: SWE vs. AMSR-E T_B Data







- Brightness temperatures are five day moving averages centered on in situ measurement dates.
- Stronger statistical agreement and brightness temperature range with 37V-10V vs. 37V-19V.
- Strong relationship between 19V-10V although range is small.
- Similar, but slightly weaker results with H-pol data.

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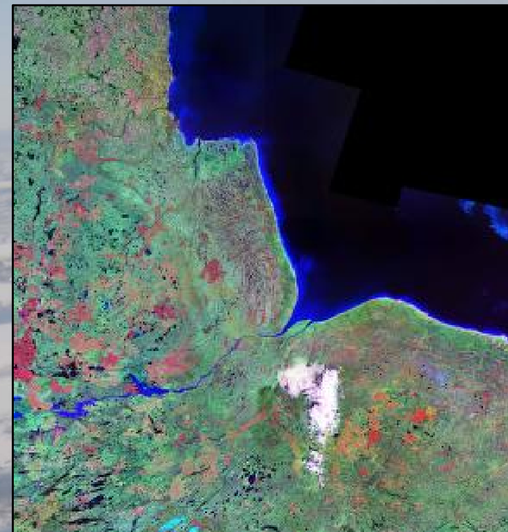
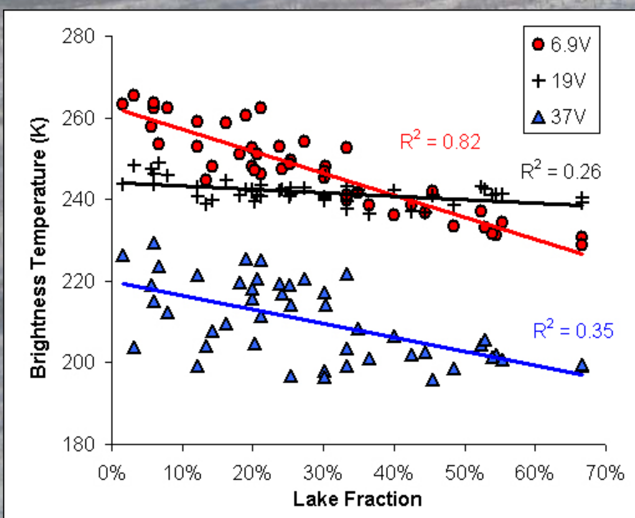
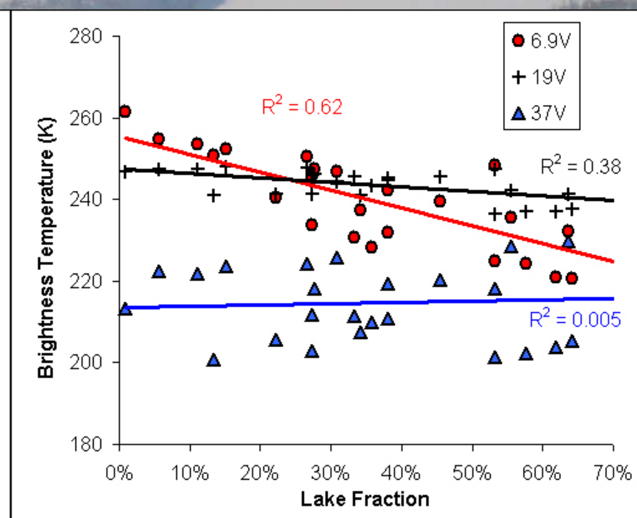
Sub-Grid Issues: Impact of Lake Fraction



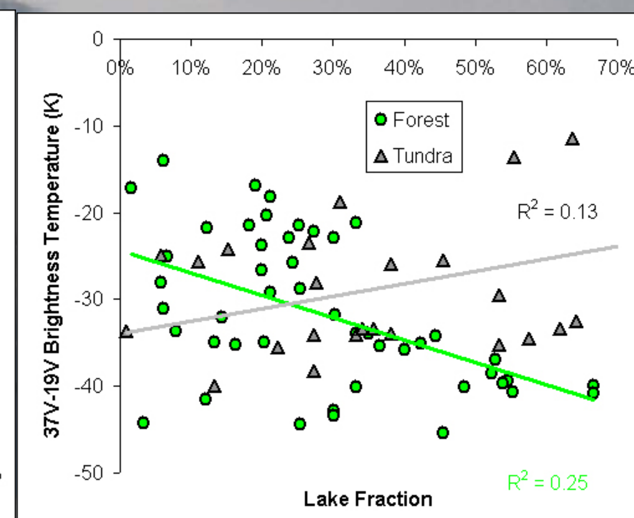
- Airborne brightness temperatures aggregated at multiple scales: 250, 500, 1000, 2000 km
- Lake fraction within each aggregation unit determined from Landsat imagery



Forested Sites



Tundra Sites



37V-19V

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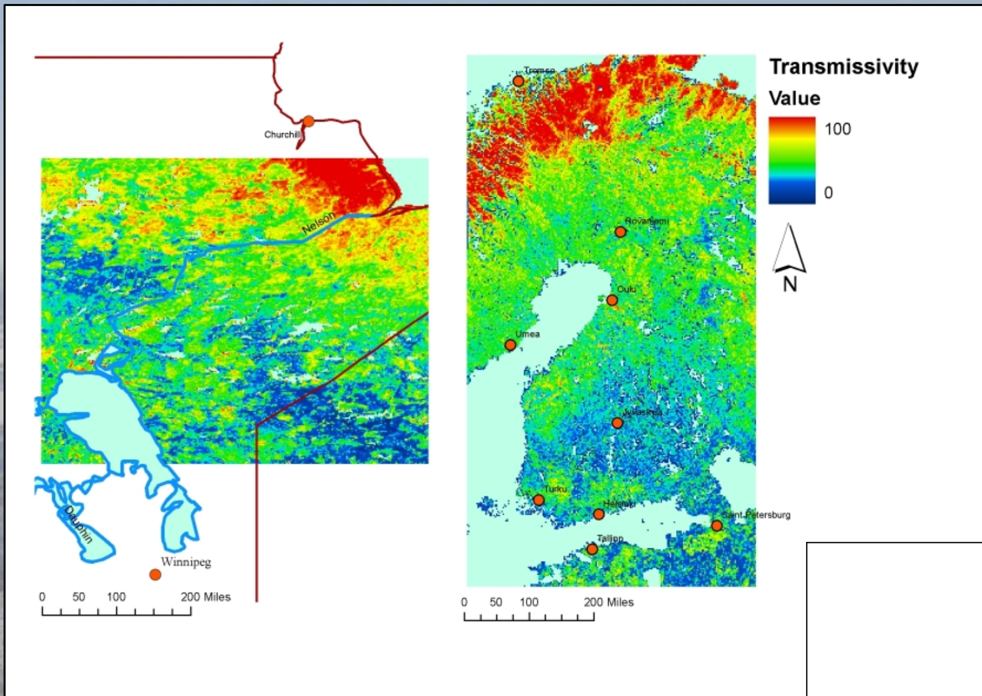
Sub-Grid Issues: Vegetation

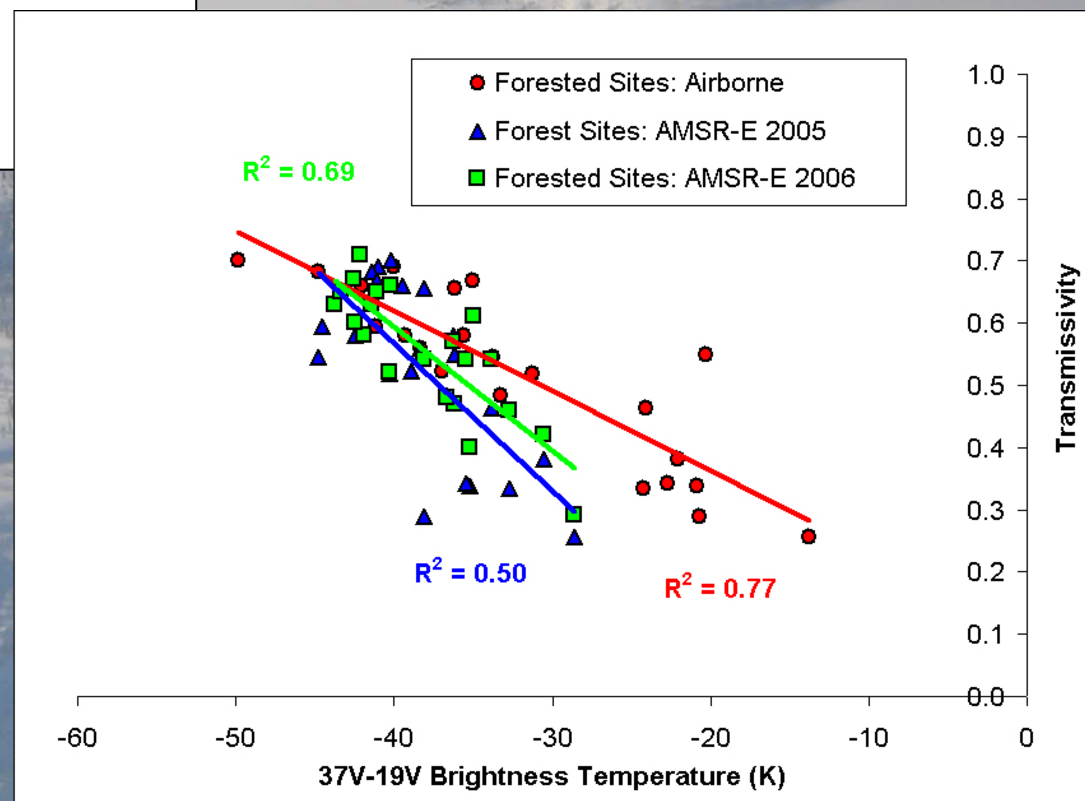


$$\hat{t}^2 = \frac{\rho(SCA = 100\%) - \rho_{forest}}{\rho_{snow} - \rho_{forest}}$$

Transmissivity:
Calculated for each cell using MODIS data with dry snow cover conditions (Metsamaki et al., 2005)

****Collaboration with Finland (Met. Service, Environment, TEKES)***

➢ **Similar relationship at airborne and satellite scales between 37V-19V and transmissivity.**



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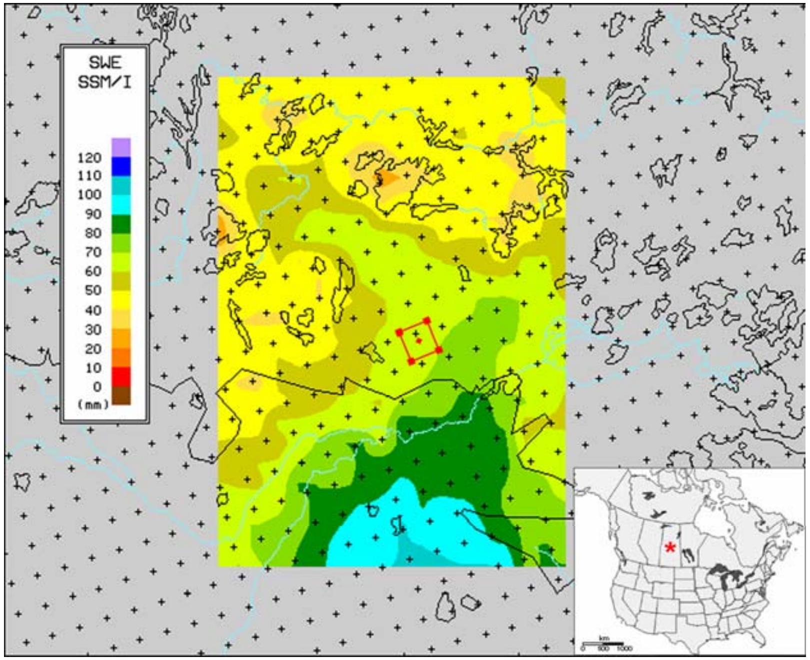
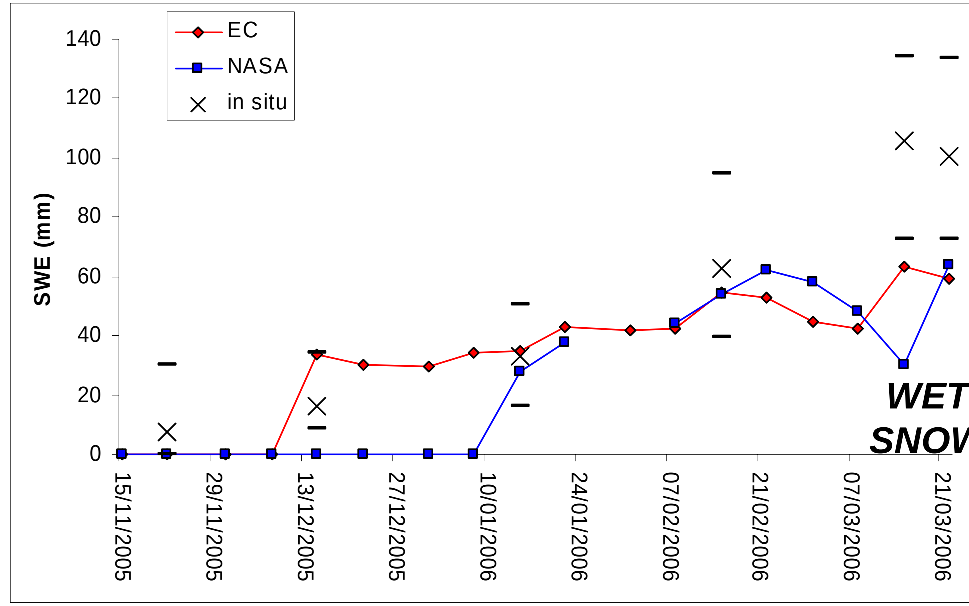
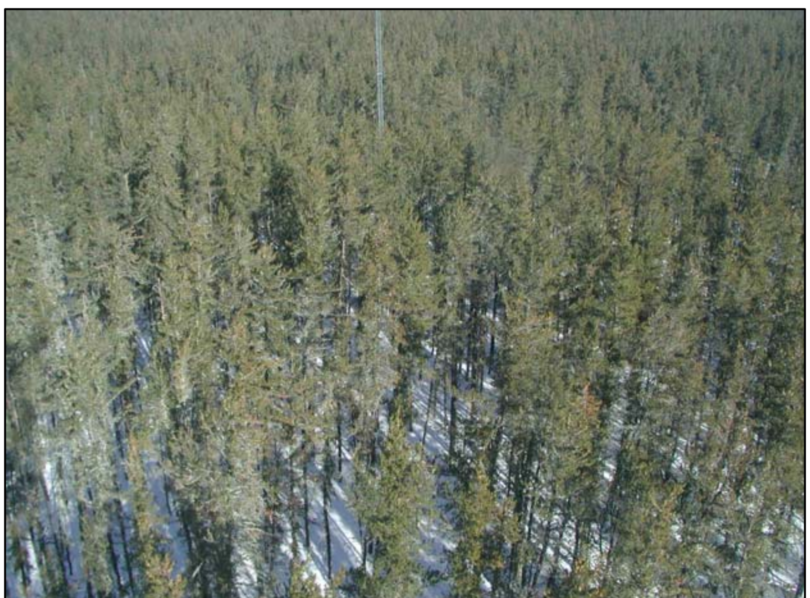
Boreal Ecosystem Research and Monitoring Sites







- Mixed forest environment

- Snow surveys conducted in each land cover type:
-species specific mature stands
-sequence of harvested stands: 25-yr plantation to clear cut

Summary

- **Airborne and ground campaigns conducted in Canada during 2005 and 2006 have produced datasets well suited for algorithm evaluation.**

- **EC and NASA algorithms performed in a very similar fashion across Canadian prairie provinces during 2005/06 winter season.**

- **Satellite scale relationships between Tb and SWE are moderately strong across the northern boreal forest:**

    - **Use of 37-10 GHz data improves relationships, particularly in regions with deep snow**
    - **Use of 37-10 GHz reduces vegetation influence**
    - **19-10 GHz discriminates deep from shallow snow**

- **Airborne 37-19 and 6.9 GHz measurements influenced by lake fraction (*relationships at the satellite scale, remain to be explored*)**

    - **Over forested regions high lake fractions *increase* 37-19 GHz difference**
    - **Over tundra regions high lake fractions *decrease* 37-19 GHz difference**
    - **Lake fraction can be potentially be addressed using 6.9 GHz data**

Variability and Change in the Canadian Cryosphere

Can. contribution to the "State and Fate of the Cryosphere" IPY 105

Photo: *Vital Arctic Graphics*, UNEP, GRID-Arendal, 2005

Activities
Cryospheric information contributing to the IPY snapshot
Cryosphere-climate variability and feedbacks
Improved representation of Arctic processes in CLASS
Simulation of the cryosphere in climate models
The human dimension
Canadian cryospheric data portal for IPYDIS

Planned IPY snow cover field campaigns in Canadian tundra regions:

April-May 2007 NWT
Jan-Feb 2008 Northern Quebec
April-June 2008 NWT & Arctic Islands

Acknowledgments

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National Snow and Ice Data Center
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